To date the Murta Member has hosted two commercial oil discoveries. The largest is the Dullingari-Murta Field which is a combined structural-stratigraphic play. Lenticular winnowed shoreline-bar sands provide the main reservoir in the field and subtle structural movements have apparently controlled porous sand development later modified by complex diagenetic processes. Proximal turbidite sand flows and delta distributary channels have only produced small oil flows, largely due to the presence of quartz-calcite cements and limited reservoir continuity. The Jackson Field discovery occurs in a relatively sandy sequence deposited close to source areas. The main reservoir is a proximal delta front deposit, possibly modified by wave action. The sources of oil at Dullingari and Jackson are interpreted to have been silty shales within the Murta Member which are locally enriched in exinite (mainly alginite, sporinite and cutinite), particularly in the lower part of the sequence.

With reference to the regional depositional model (Fig. 6) the hydrocarbon potential of the Murta Member is summarised as follows:

(1) Distal lacustrine facies: contains adequate source rocks but reservoir quality sands are sparse. Prospectivity is regarded as moderate to poor.

(2) Intermediate lacustrine facies: source rocks are present and potential reservoirs although not abundant, include shoreline, delta front, distributary channel and turbidite facies. Prospectivity is regarded as high.

(3) Proximal lacustrine facies: reservoir quality sandstones including delta front and proximal lacustrine fan facies, are relatively abundant and prospectivity is regarded as very high.

Overall, it is considered that combined structural-stratigraphic plays of the Dullingari type are viable targets, especially along the '48-5' shoreline-bar sand trend. Structural plays will probably be more rewarding to the north and east where reservoir quality sands are relatively abundant.

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*Geological Society of Australia Special Publication No. 12,* 85-95

# Margin of the Eromanga Basin South Australia: a review

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## ABSTRACT

In publications prior to 1978 the term Great Artesian Basin was commonly used to refer to the Eromanga Basin in South Australia. Some important early contributions were by Hudleston and Howchin (palaeontology), Jack (stratigraphy and structure), and Sprigg (petroleum potential). Current stratigraphic nomenclature is based on geological mapping by Freytag, Forbes, Wopfner and others and the biostratigraphy of Ludbrook. Stratigraphic units in common use on Geological Survey maps are (from oldest to youngest): Algebuckina Sandstone (Jurassic, main artesian aquifer); Cadna-owie Formation (Neocomian to Aptian); Bulldog Shale, marine Aptian to Albian; Oodnadatta Formation, marine Albian claystone, sandstone and limestone, with Coorikiana Member and Mount Alexander Sandstone Member; Winton Formation (Cenomanian). Although Bulldog Shale and Oodnadatta Formation have been grouped together as Marree Subgroup, it is probable that the original Marree Formation did not include the upper sandstone (Mount Alexander Sandstone Member) in the Oodnadatta Formation. It is recommmended that Marree Subgroup refer to the sequence in the original Marree Formation, with the exception of the basal Trinity Well Sandstone Member.


## INTRODUCTION

In this review of the geology of the margin of the Eromanga Basin, emphasis will be on exposure and surface expression of the basin and the aspects which most concern a geologist engaged in regional geological mapping. Figure 1 is a general locality map. Prior to 1978 the term Great Artesian Basin was used in publications of the South Australian Department of Mines and Energy to refer to the Eromanga Basin.

## HISTORICAL

Studies prior to the current era of geological mapping in the Great Artesian Basin in South Australia were all related to the search for groundwater. These include geological reconnaissance, palaeontology and investigation of groundwater. Rawlinson (1878) quoted by Ward (1946, p. 42) appears to have made the earliest prediction of large supplies of underground water in an interior basin. Between 1894 and 1895 Mesozoic molluscs and foraminifera from the Lake Eyre region were collected during reconnaissance survey and drilling by the South Australian Government. The fossils were described by Hudleston (1884, 1890) and Howchin (1886, 1893*a, b,* 1895). A collection of geological specimens, including Mesozoic fossils, from South Australia was exhibited by the Government Geologist at the Colonial Exhibition in London in 1886. In 1887 Scoular made general geological observations and collected fossils northwest of Marree. Brown (1892*a, b*) reported on his wide-ranging reconnaissance around the northern edge of the Flinders Ranges and the Lake Eyre region during which he made extensive collections of fossil material and noted mound springs and anomalous boulders of quartzite and porphyry within the Cretaceous shales. The first to describe the stratigraphy and structure of the Great Artesian Basin was Jack (1930) who used the stratigraphic subdivision of Whitehouse (1928) namely "Jurassic sand", Morven Formation ("transition series"), Roma Formation, Tambo Formation and Winton Beds, which approximates closely the current lithostratigraphic subdivision. He was followed by Ward (1946). In 1955 Woodard and Glaessner & Rao published details of the lithology and fossil plant remains of the sandy sequence below the marine Cretaceous in the northern Flinders Ranges.

The present era of exploration for oil and gas was ushered in by R. C. Sprigg and his colleagues of Geosurveys of Australia Limited who in their summary of the geology of the Great Artesian Basin in South Australia (Sprigg, 1958) noted that traces of oil and gas were present throughout the basin and the petroleum potential was being investigated.

Geological Survey mapping of the margin of the Eromanga Basin began with the production in 1961 of the *Gardiner, Moolawatana* and *Paralana* one-mile geological maps (Campana *et al.*, 1961*a, b, c*) showing the edge of the northeastern Flinders Ranges. Compilation was by R. P. Coats and mapping by Coats, Horwitz, Thatcher, Campana and Webb. These maps used the Queensland stratigraphic nomenclature of Blythesdale Group, Roma Formation and Tambo Formation. The *Callanna, Marree* and *Wilpoorinna* one-mile geological maps appeared in 1963 and used similar nomenclature (Webb, *et al.*, 1963; Coats *et al.*, 1963; Forbes & Coats, 1963).

The first use of local stratigraphic nomenclature on Survey maps of the Eromanga Basin appeared on the 1:250 000 geological maps MARREE (Forbes *et al.*, 1965) and

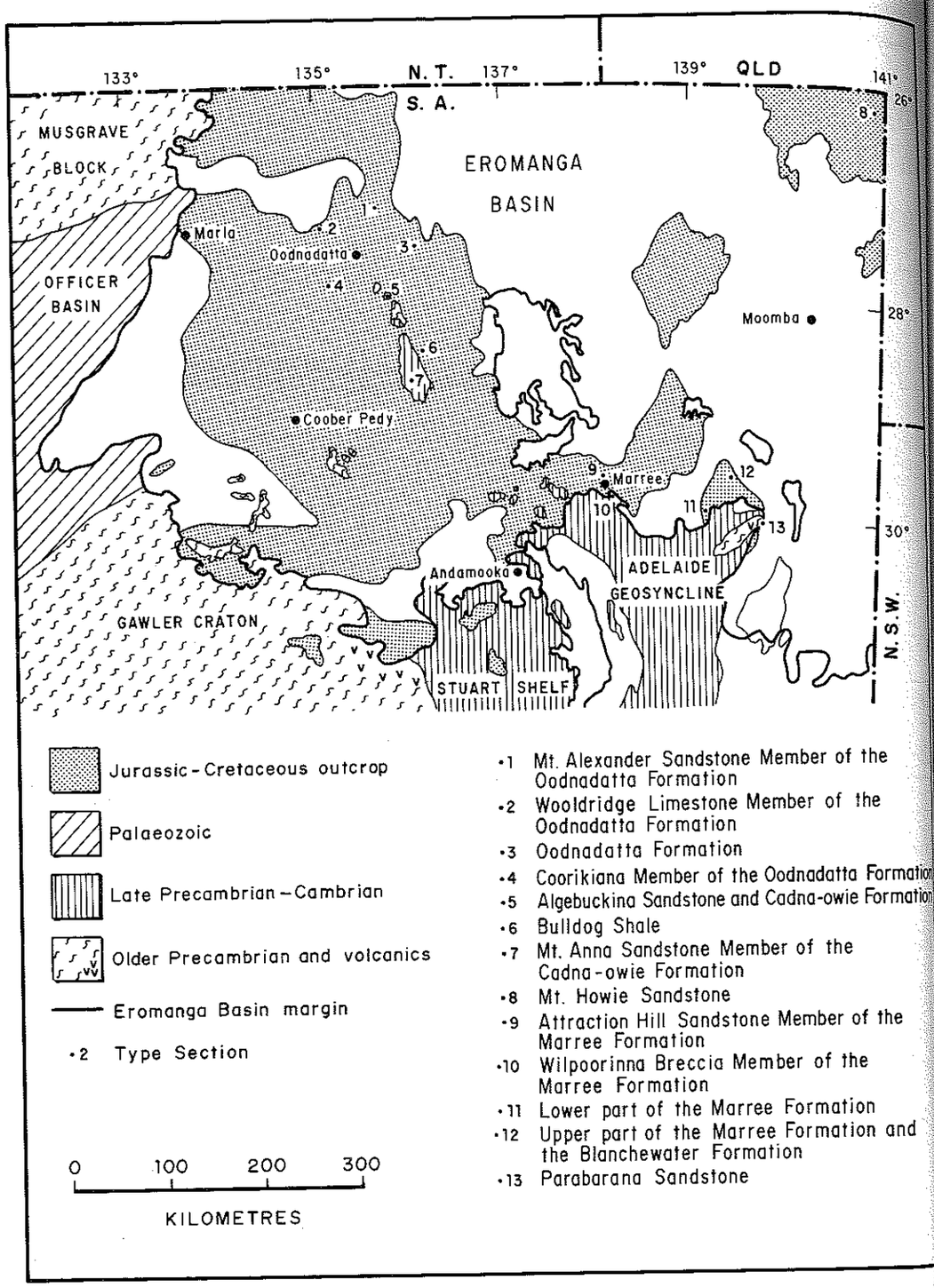



Fig. 1. Eromanga Basin in South Australia: regional geology. Terms refer to original definitions. Note that the following revisions are suggested later: Mt Alexander Sandstone, Coorikiana Sandstone, Marree Subgroup, Wilpoorinna Breccia.



OODNADATTA (Freytag *et al.*, 1967). Ludbrook (1966) produced a major contribution on Cretaceous biostratigraphy of the Great Artesian Basin in South Australia and provided a comprehensive biostratigraphic framework for both surface and subsurface studies. Wopfner, Freytag & Heath (1970), in another major contribution, extended the stratigraphy established in the Oodnadatta region over a great part of the Eromanga Basin in South Australia. The more recent Survey maps and reports are summarised in Figure 2.

## STRATIGRAPHY

The common nomenclature used on recent Geological Survey maps of the Eromanga Basin in South Australia is shown in the left hand part of Figure 3.

### *Algebuckina Sandstone*

The name Algebuckina Sandstone was first used in its current sense on the OODNADATTA 1:250 000 geological map (Freytag *et al.*, 1967) and was formally defined by Wopfner *et al.* (1970). The type section is 0.8 km southwest of the disused Algebuckina railway siding. Age is thought to be Late Jurassic to possibly Early Cretaceous, based on microfloral studies (Harris, 1970)*. The lithology is typically white, kaolinitic, quartz sandstone and conglomerate composed of well-rounded quartz pebbles. The sandstone is cross-bedded, contains plant fossils and is thought to represent a continental, mainly fluvial environment. Ambrose (1980) suggests a braided-stream environment.

Exposures of the Algebuckina Sandstone are best seen in the OODNADATTA and WARRINA regions, but basal sandstones thought to be equivalent have been recognised along a great part of the marginal Eromanga Basin (Fig. 4) and include the Village Well Formation in the MARREE area. Thickness data in the northeast were gathered from Nugent (1969: Birkhead and Mooga Formation and equivalents). Areas of non-deposition or erosion occur around the northeast Flinders Ranges, southeast and southwest of Lake Eyre and in the far west. In the northwest, in the ABMINGA area it is difficult to distinguish the Algebuckina Sandstone from the overlying Cadna-owie Formation. Field observations by Ambrose (1980) and others suggest an interval of widespread chemical weathering of the Algebuckina Sandstone prior to deposition of the Cadna-owie Formation.

### *Cadna-owie Formation*

The name Cadna-owie Formation was used on the OODNADATTA 1:250 000 geological map (Freytag *et al.*, 1967) and the formation was defined by Wopfner, Freytag & Heath in 1970. The type section is 4 km west-southwest of the disused Algebuckina railway siding. Age is thought to be Neocomian to Aptian. Lithology is typically fine- to medium-grained, brownish sandstone. It is in parts calcitic, feldspathic,

* This refers to a locality near Ingomar Homestead, not the type section, which is Harris (*in* Wopfner *et al.*, 1970). The Ingomar microflora is Late Jurassic.

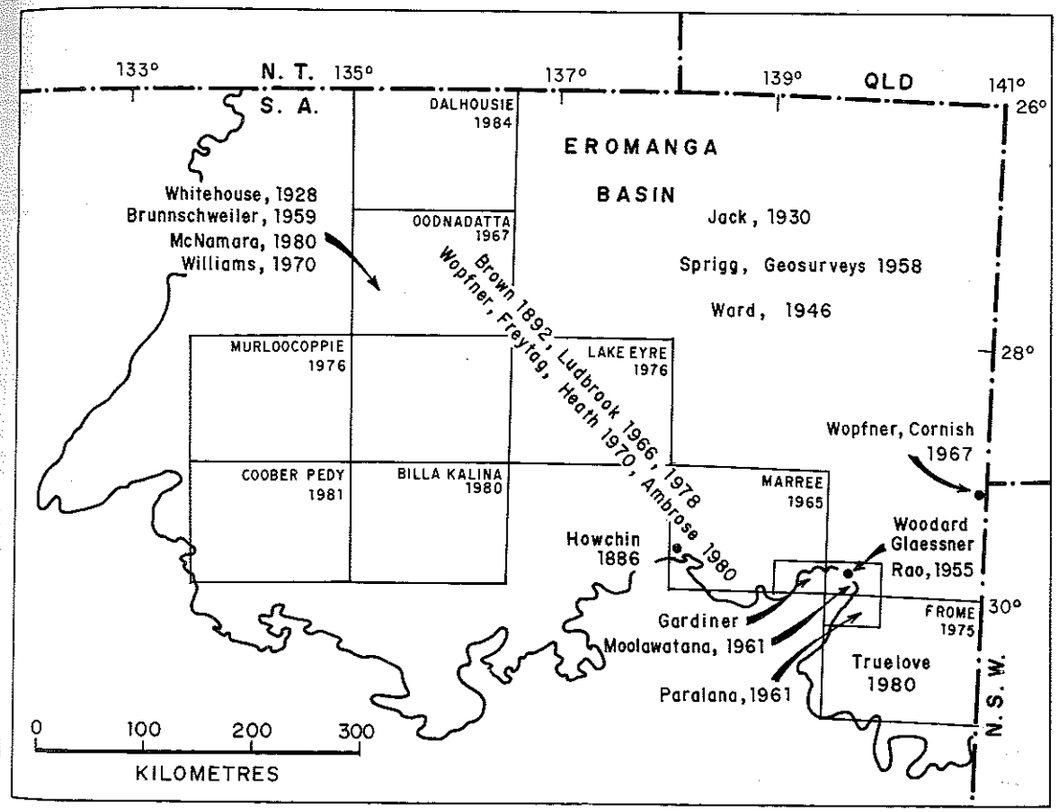



Fig. 2. Eromanga Basin in South Australia: locations of geological contributions.

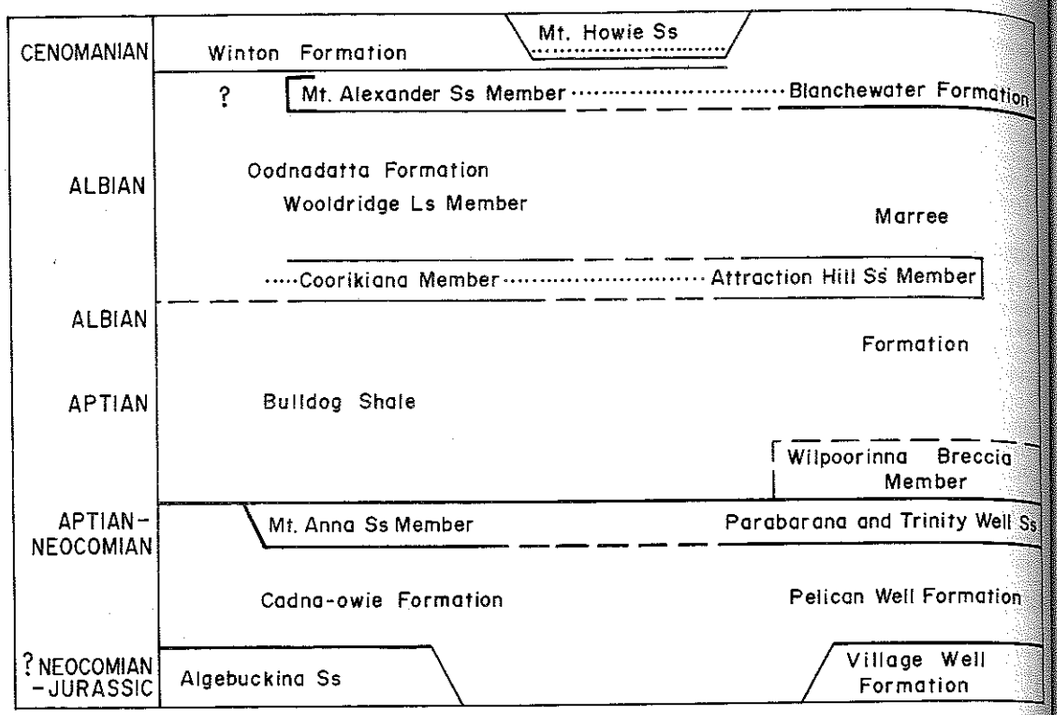



Fig. 3. Eromanga Basin in South Australia: stratigraphic units. Left hand side shows original terminology for commonly used stratigraphic units of Jurassic-Cretaceous in South Australia. On right are map units originally used on MARREE and COPLEY. Note that Marree Formation now revised to Marree Subgroup is not everywhere divisible into upper and lower members and is overlain by a probable equivalent of the Mt Alexander Sandstone.

silty and micaceous, and also contains pebbles and boulders of quartzite. Pyrite is commonly present and may occur as large concretions. Carbonaceous shale is present in some areas. The Mount Anna Sandstone Member of the Cadna-owie Formation appears to occur mainly in the upper part of the Cadna-owie Formation. It has its type section at Mount Anna and is characterised by rounded pebbles of porphyritic rhyolite in a medium- to coarse-grained feldspathic sandstone. The Cadna-owie Formation is more widely distributed than the Algebuckina Sandstone and represents shallow marine to fluvial conditions (Fig. 5). Thickness data in the northeast were gathered from Nugent (1969). In the MARREE area it is represented by the Pelican Well Formation and Trinity Well Sandstone. Wopfner *et al.* (1970) noted a trough of fluvial Mount Anna Sandstone northwest of Lake Torrens. This, and evidence of northeasterly-directed palaeocurrents, support the derivation of porphyry boulders from the Gawler Range Volcanics. In the Mount Painter region Giles & Teale (1979) noted that prophyry boulders in the Cretaceous were locally derived. Boulders of Devonian quartzite have been noted by Campbell *et al.*, (1977). The Cadna-owie Formation may lie transitionally above the Algebuckina Sandstone or may overlie a low-angle unconformity.

### *Bulldog Shale*

The Bulldog Shale was defined by Freytag (1966) at a reference section 8 km south of Bulldog Creek, east of the Peake and Denison Ranges (Fig. 6). It is of Aptian and Albian age (Ludbrook, 1966, 1978, 1980; McNamara, 1980; Morgan, 1980) and is characterised by dark fossiliferous shale, claystone and concretionary limestone. Thickness in Oodnadatta 1 is 170 m. Flint *et al.* (1980) have described fossiliferous Devonian quartzite boulders from the base of the Bulldog Shale. These are thought to have possibly originated as a reworked submarine debris-flow deposit, related to basin margins and basement highs. Ultimate derivation is thought to have been from the Amphitheatre Group, N.S.W., via Carboniferous-Permian glacial ice.

Around the northeast Flinders Ranges the Bulldog Shale appears to pass imperceptibly up into the Oodnadatta Formation of similar lithology, but over most of the area the base of the Oodnadatta Formation is marked by its sandy Coorikiana Member.

### *Oodnadatta Formation*

The Oodnadatta Formation of Albian age is lithologically similar to the Bulldog Shale. At the type section at Mount Arthur (Freytag, 1966) it is over 140 m thick. The basal Coorikiana Member ('Coorikiana Sandstone Member', Pitt, 1978) of the Oodnadatta Formation has a type area in Coorikiana Creek 40 km southwest of Oodnadatta. It is composed of fine-grained feldspathic and glauconitic sandstone with some coarser-grained and pebbly lenses. Coorikiana Sandstone is the name used for this unit by Thomson (1980) and is now the preferred term for the Coorikiana Member (Moore & Pitt, 1982).

The Wooldridge Limestone Member of the Oodnadatta Formation occurs typically over about 8 m thickness in Wooldridge Creek, northwest of Oodnadatta, where it is composed of calcareous and sandy siltstone with limestone concretions. It contains an ammonite fauna of Late Albian age (Ludbrook, 1966, 1978; McNamara, 1980).

The Mount Alexander Sandstone Member of the Oodnadatta Formation (Freytag, 1966) was defined from a type section 49 m thick at Mount Alexander, north-northeast of Oodnadatta. It is characterised by very fine-grained glauconitic sandstone with shaley coarse siltstone and ferruginous carbonate beds. It is tentatively correlated with the lower part of the Blanchewater Formation (MARREE area) and also the Mackunda Formation. For this reason it is possibly best separated from the Oodnadatta Formation (Moore & Pitt, 1985).

### *Marree Subgroup*

The term Marree Subgroup, which first appeared on the South Australia 1:1 000 000 geological map of 1980, has been used to refer to the sequence, base of Bulldog Shale to top of Oodnadatta Formation. It should be noted that this application, which has not yet been formalised in the literature, is not the same as Marree Formation which terminated at the base of the Blanchewater Formation below the base of the Winton equivalent in the Marree area. Marree Formation, in its original definition (Forbes, 1966) also included at its base a sandstone (Trinity Well Sandstone Member of the Marree Formation) which is probably equivalent to the Mount Anna Sandstone Member of the Cadna-owie Formation. It is suggested here (with Moore & Pitt, 1985) that Marree Subgroup be used in place of Marree Formation, as described below.

The type area of the lower Marree Formation is in the southeast of the MARREE map area, near Village Well. Relationships are shown in Figure 7. The Trinity Well Sandstone Member of the Marree Formation has a sharp basal conglomeratic contact on pebbly and carbonaceous shale of the Pelican Well Formation and grades up into siltstones of the Marree Formation containing Aptian microfossils (Ludbrook, 1966). In spite of this relationship it is reasonable to accept the proposal of Wopfner *et al.* (1970) that the Trinity Well Sandstone Member is probably equivalent to the Mount Anna Sandstone Member of the Cadna-owie Formation. If the Trinity Well Sandstone is separated from the Marree Formation, the base of the Marree Formation becomes more readily mappable as the base of a shale sequence. In places near Marree, the base of the Marree Formation is composed of a shaley marine Aptian breccia, the Wilpoorinna Breccia Member, resting directly on the Proterozoic.



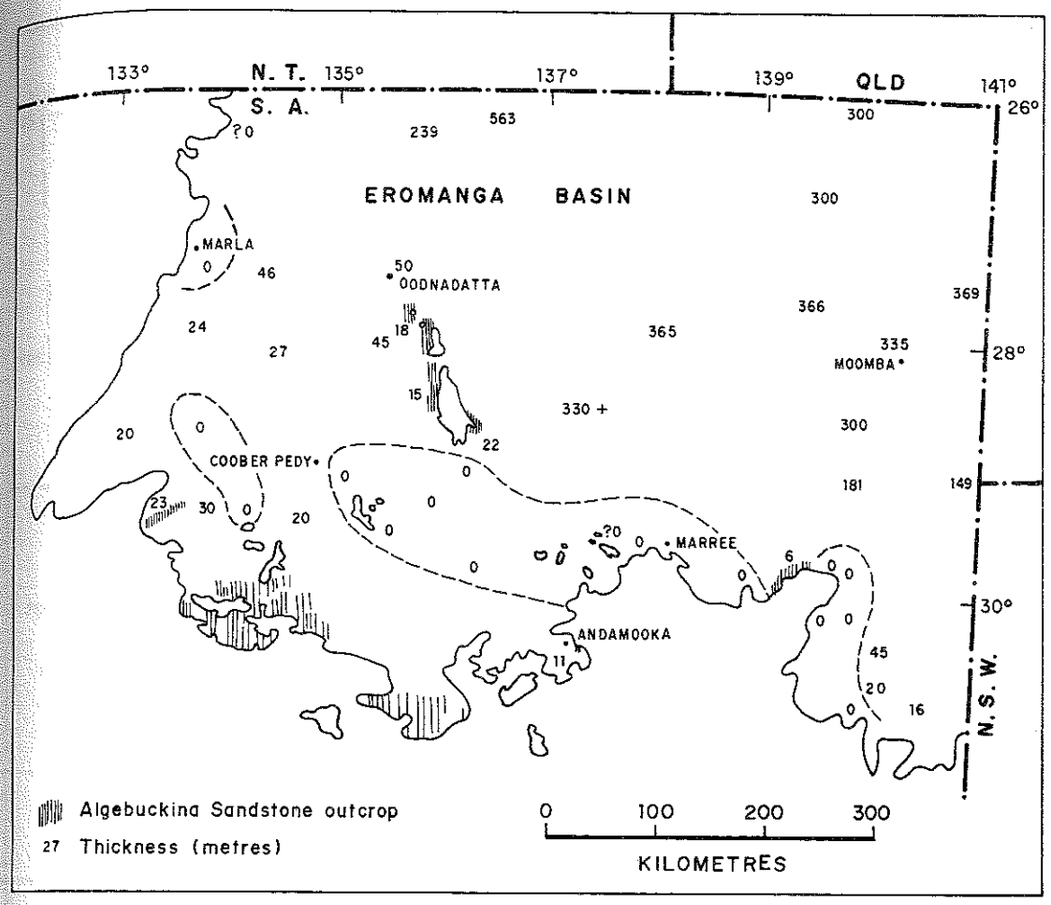



Fig. 4. Eromanga Basin in South Australia: Algebuckina Sandstone thickness and outcrop distribution. Dotted line shows very approximately limits of areas of absence of Algebuckina Sandstone.

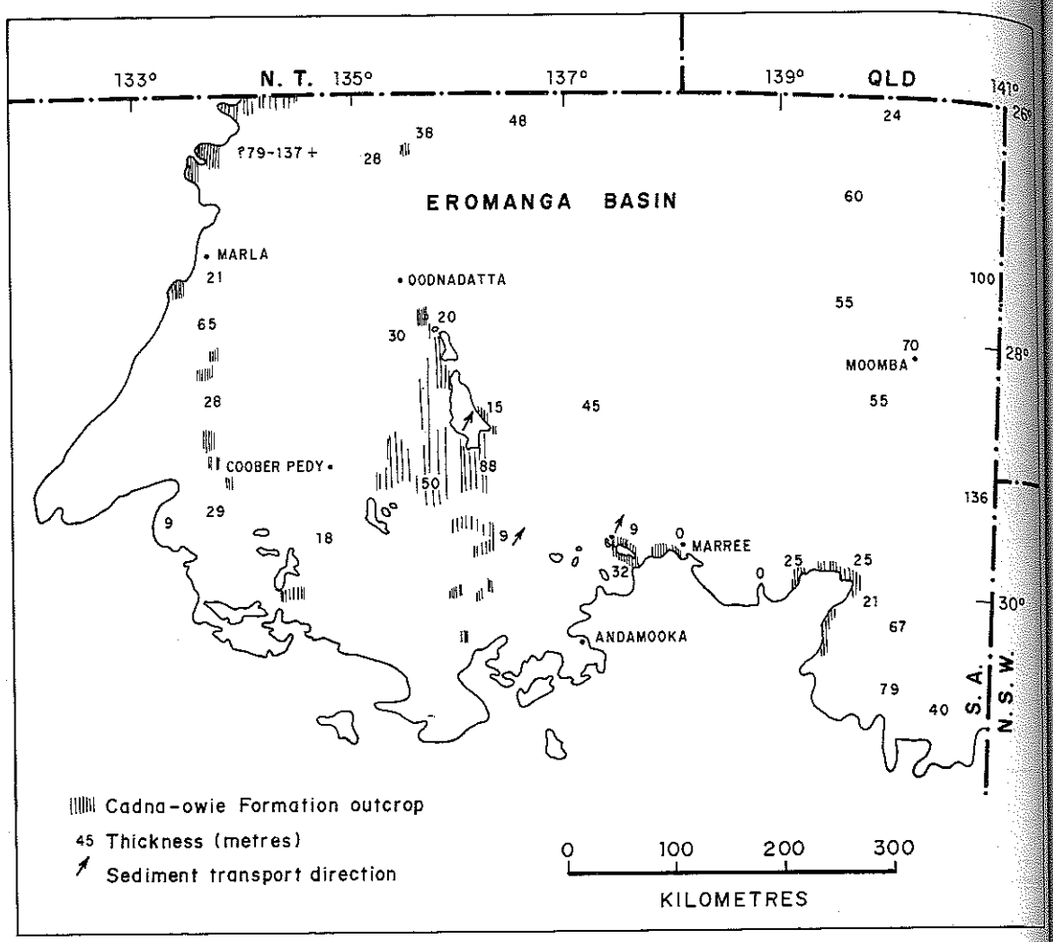



Fig. 5. Eromanga Basin in South Australia: Cadna-owie Formation thickness and outcrop distribution.

The type section of the uppermost Marree Formation and overlying Blanchewater Formation is provided near Reedy Springs, southeastern MARREE region. Relationships are shown in Figures 8 and 9. The top of the Marree Formation (now top of Marree Subgroup) was chosen at the incoming of the lower sands of the Blanchewater Formation, probable equivalent of the Mackunda Formation (Exon & Senior, 1976), because this appeared to be the most readily mappable boundary. Winton Formation was presumed to be represented in the upper part of the type section of the Blanchewater Formation but no mappable boundary was recognised. In its eastern type region the Marree Formation is not divisible into upper and lower members because of the absence of suitable marker beds such as the Coorikiana Sandstone.

From this, it would seem that if the term Marree Subgroup is to be formalised, it should be applied only to a shaley sequence equivalent to Bulldog Shale plus the Oodnadatta Formation without the Mount Alexander Sandstone.

### *Mount Howie Sandstone*

Above the Mackunda Formation equivalent as described at Reedy Springs, Winton Formation is widely exposed, but will not be described further here. The Mount Howie Sandstone was described and defined by Wopfner (1963) in the Cordillo region as a fluviatile unit incised into the Winton Formation. It is composed of white cross-bedded sandstone and shale-pebble conglomerate. Age may possibly be Turonian. Very similar cross-cutting, fluvial, kaolinitic, sandy beds have been noted northeast of Marree (Forbes, 1972). This unit, if correctly identified, has thus approached quite close to the basin margin.

## CONCLUSION

Although there is some duplication of stratigraphic names, the various units can generally be recognised and correlated. Lithologies characteristic of the Algebuckina Sandstone are



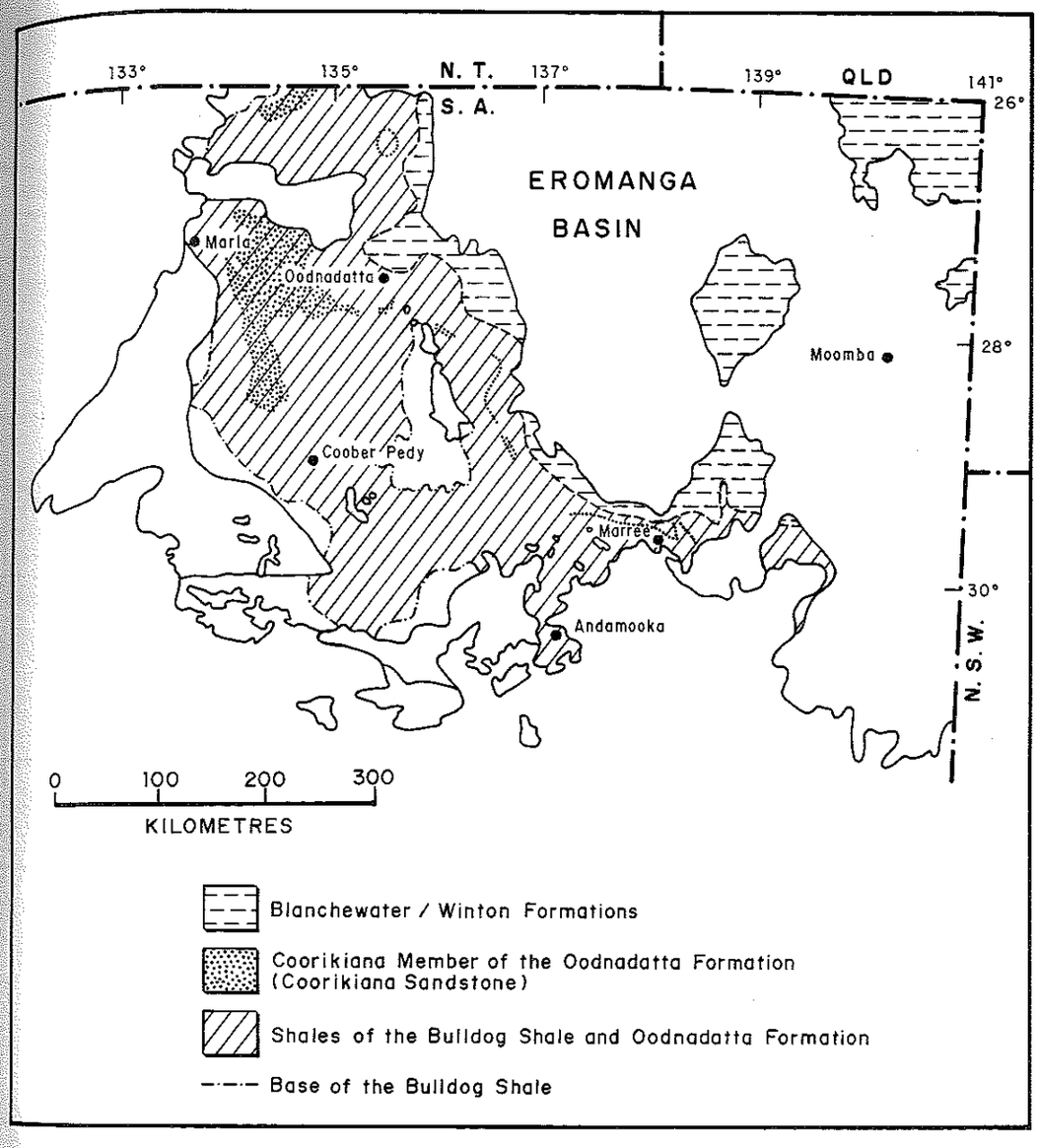
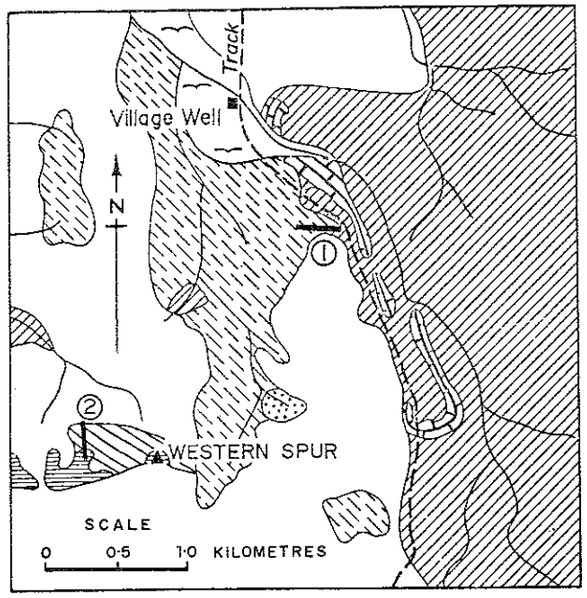



Fig. 6. Eromanga Basin in South Australia: Bulldog Shale to Winton Formation. Distribution of outcropping Cretaceous above Cadna-owie Formation.

recognisable, though not continuously, over wide areas. The Cadna-owie facies is widespread and generally recognisable. The mainly shaley Bulldog-Oodnadatta sequence is the most extensive in area, while it seems the equivalent of the Mackunda Formation may be fairly continuous in both outcrop and in drillholes as indicated by Ludbrook (1966). It is recommended that in future mapping Marree Subgroup should refer to the same sequence as Marree Formation and an endeavour be made to map the Mackunda Formation.

Following the suggestions of Moore & Pitt (1982, 1985) it is agreed that preferred nomenclature within the Marree Subgroup be (from below) Wilpoorinna Breccia, Bulldog Shale, Coorikiana Sandstone and revised Oodnadatta Formation. Above the Oodnadatta Formation are the probably equivalent Mount Alexander Sandstone and Mackunda Formation, underlying the Winton Formation. The

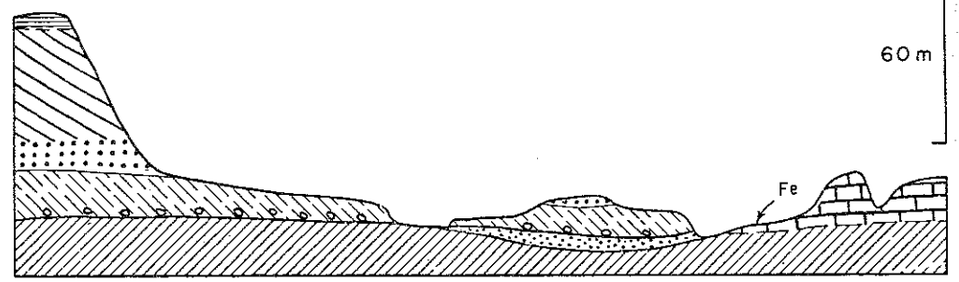



GEOLOGICAL SKETCH PLAN showing location of type-sections near Village Well.
① Village Well Formation and Pelican Well Formation

② Lower part, Marree Subgroup

SW NE

DIAGRAMMATIC SECTION NEAR VILLAGE WELL




LEGEND

QUATERNARY
- Alluvium
- Gravels

TERTIARY
- Silcrete

CRETACEOUS
- Marree Subgroup (Bulldog Shale)
- Trinity Well Sandstone (Mount Anna Sandstone Member ?)
- Pelican Well Formation (Cadna-owie Formation)

? JURASSIC – CRETACEOUS
- Village Well Formation (Algebuckina Sandstone)

PRECAMBRIAN
- Wilpena Group: Quartzite, siltstone, marble

Fe Ironstone

Fig. 7. Eromanga Basin in South Australia: type sections near Village Well (location 11 in Fig. 1). Lower Marree Subgroup and underlying Mesozoic, southeast of Marree.



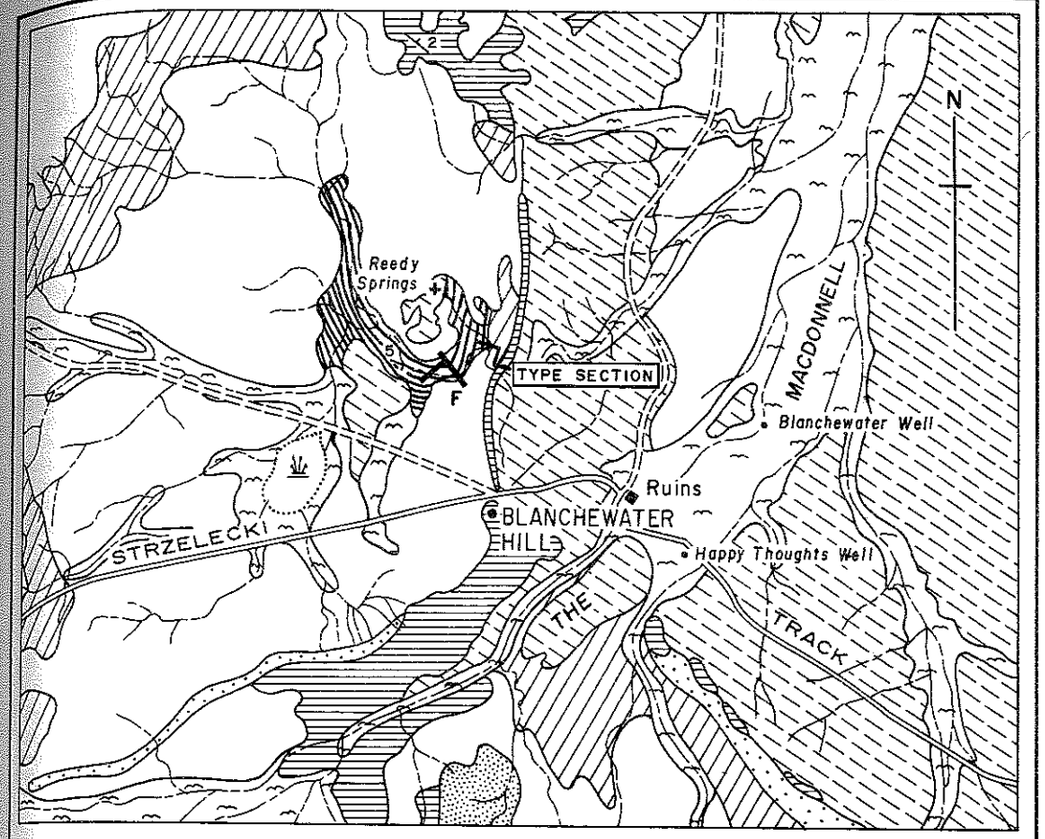



Fig. 8. Eromanga Basin in South Australia: geology of Reedy Springs area (location 12, Fig. 1). Type section of upper part of Marree Subgroup and Blanchewater Formation, southeast of Reedy Springs on Blanchewater 1:63 360 sheet. Intersecting faults (F) have springs along them and delineate a depressed block of Blanchewater Formation. Reedy Springs occur within a minor dome bounded to the east by steeply-dipping, monoclinally folded silcrete. Adapted from Forbes (1966).

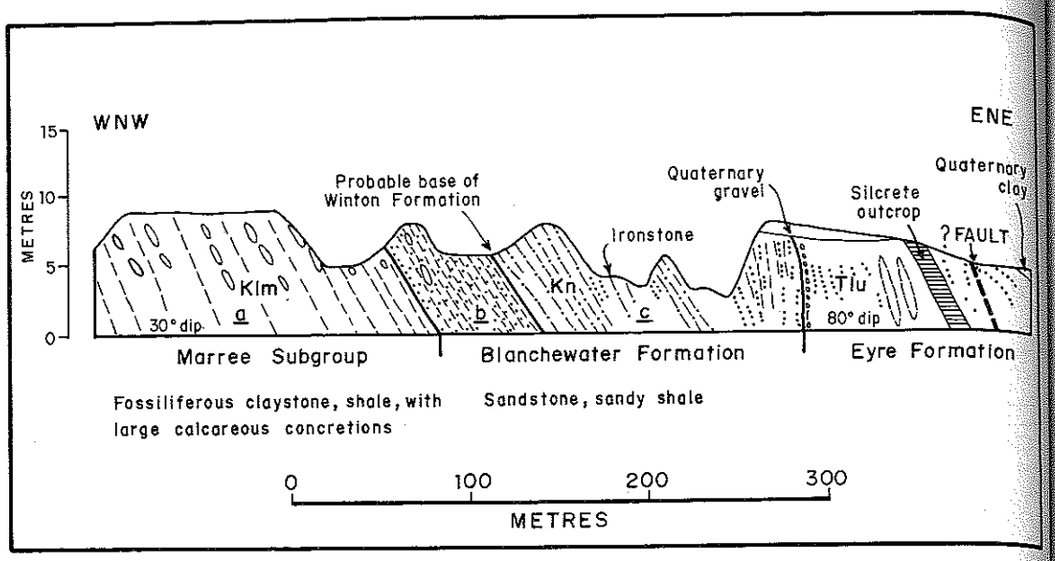



Fig. 9. Eromanga Basin in South Australia: diagrammatic section southeast of Reedy Springs, MARREE region (location 12, Fig. 1). Type sections of upper Marree Subgroup (originally Marree Formation) and Blanchewater Formation. Probable equivalence is: *(a)* Wooldridge Limestone Member of Oodnadatta Formation, *(b)* Mount Alexander Sandstone and Mackunda Formation, *(c)* Winton Formation. Adapted from Forbes (1966).

term 'Blanchewater' has been omitted from Table I below but may be needed if it becomes impractical to map the Mackunda-Winton boundary.

TABLE I. Suggested nomenclature.

| |
|---|
| Mount Howie Sandstone |
| Winton Formation |
| Mackunda Formation, Mount Alexander Sandstone |
| MARREE SUBGROUP: |
| Oodnadatta Formation (revised) |
| Coorikiana Sandstone |
| Bulldog Shale |
| Wilpoorinna Breccia |
| Cadna-owie Formation |
| Algebuckina Sandstone |

## ACKNOWLEDGEMENTS

I am grateful to colleagues of the S.A. Geological Survey, Dr D. Gravestock, Dr N. H. Ludbrook, Dr P. S. Moore and referees for helpful comments during preparation of the paper.

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